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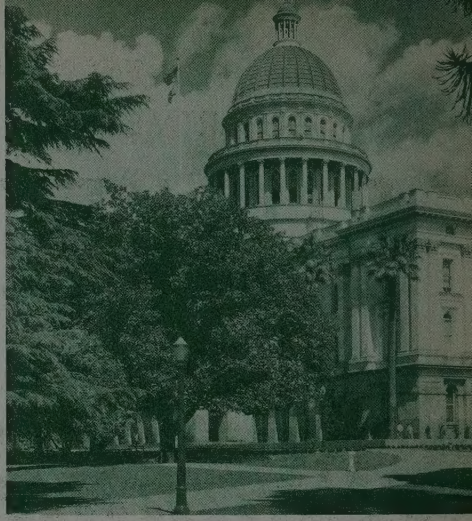

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COVER: Aerial view of a Sacramento County (Natomas District) pear orchard showing pear-decline affected trees scattered throughout the orchard. Photograph by courtesy of the Department of Plant Pathology, University of California, Davis.

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Pear Decline in Italy

Thomas A. Shalla and Luigi Chiarappa [1]

Introduction

By CARL W. NICHOLS, Plant Pathologist
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About a million pear trees have either died or become severely debilitated by the pear decline disorder in California since it first appeared in 1959. Large numbers also have been affected in the Pacific Northwest where the disorder was first seen about 10 years earlier. The disease has been recognized in 21 counties in California from Humboldt in the north to San Diego in the south. The only California counties with appreciable amounts of commercial pear acreage where pear decline has not been definitely diagnosed are Kern and Los Angeles.

A large group of plant scientists have been and are working in California and elsewhere to determine the cause of the pear decline and to develop methods for its control. During these studies the investigators have observed many similarities between pear decline as it occurs along the Pacific Coast and the Moria disease of pear in Italy. In order to determine if these two disorders are identical and to gain information from the Italian investigators that might be helpful, the Program Committee of Pear Zone No. 1 [2] made money available to send two plant scientists, Dr. Thomas A. Shalla, Assistant Plant Pathologist for the University of California, and Dr. Luigi Chiarappa, Plant Pathologist for the Di Giorgio Fruit Corp., to Italy to study the Italian pear disorder. The following article is the report prepared by these two scientists on their Italian investigation.

In North America, pear decline first appeared in British Columbia in 1948 (9) and subsequently in the states of Washington, Oregon, and California (11). A comprehensive report on studies of a similar condition called "moria" occurring in northern Italy was published in 1949 by Baldacci *et al.* (1). Approximately 63,000 trees were killed by this disease in Italy between the years 1944 and 1947. Symptoms resembled those of pear decline, but from the literature alone it was not clear whether the two diseases were the same.

In the summer of 1961, the authors met in Italy with Professors Elio Baldacci and Elvio Refatti of the Instituto di Patologia Vegetale, University of Milan, and Dr. E. C. Blodgett of Washington State University, to determine whether moria was the same as pear decline. Shortly thereafter, Professors Baldacci and Refatti visited California where they were able to observe pear decline. Observations on moria were made in the two major pear-growing districts of Italy, located in the valleys of the Adige River and its tributaries (Trentino-Alto Adige) and in the Provinces of Ferrara and Mantova in the lower Po River Valley (Figures 1 and 2). Results of these observations, much of which has been previously described (15), are reviewed here.

Symptomatology

Symptoms of moria on the varieties Williams' Bon Chrëtien (Bartlett), Kaiser Alexander (Bosc), Moscatella piccola d'estata, and Butirre Giffard were as follows:

Foliage: Diseased trees varied in appearance. Some had only slightly limited growth and small pale leaves, while others had no terminal growth and very sparse foliage (Figures 3 and 4). Trees affected with moria appeared identical to those in North America affected by the slow phase of pear decline. Although some trees suddenly wilted

The Adige River Valley between Trento and Bolzano.

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[2] The Program Committee of Pear Zone No. 1 is the administrative agency established under the provisions of the Marketing Program for Canning Bartlett Pears.

Map of northern Italy showing distribution of moria in 1945-47 and as observed in 1961.

and died during 1944-47, no symptoms of quick decline were found during the present survey. All of the disease was of the slow decline type.

Most diseased trees were uniformily affected, exhibiting no "one-sided" effect. One Bartlett tree which was more severely affected on one side than the other was found to have a large scion root on the side of the tree which was more vigorous.

The foliage of trees affected by moria turns abnormally red in the summer. Several trees were observed near Trento during the last week of June which had symptoms of moria and had bright red foliage. According to Refatti (personal communication) many of the diseased trees observed in the present study exhibited the red leaf condition later in the summer. Reddening of pear foliage has been associated with pear decline (4).

Roots: The root systems of several trees with moria were examined. Most of the feeder roots were dead, while the larger roots were alive and apparently in good condition. No other source of root trouble was found. Trees with pear decline are similarly affected.

Graft Union Phloem: The most reliable diagnostic symptom of pear decline is a characteristic degeneration of the phloem immediately below the graft union (2, 13). This degeneration may be detectable only by microscopic examination of stained bark sections, or it may be visible as a dark brown line on the cambial face of the graft union phloem. Strips of bark were removed from the vicinity of the graft union on 45 diseased and 23 apparently healthy pear trees in the two growing districts of Italy. Each sample was observed for the presence of a brown line and then killed, sectioned, and stained for microscopic study following the method described by Schneider (14).

Thirty-one of the 45 diseased trees had degenerate phloem at the graft union characterized by sieve tube necrosis, ray distortion, and formation of abnormal replacement phloem. There was no apparent difference between the condition of the phloem of trees affected with moria and the phloem of trees with pear decline. Fifteen of the diseased trees with degenerate phloem had a distinct brown line at the graft union. Twenty-one out of 23 apparently healthy trees had normal phloem at the graft union.

Phloem necrosis was found in trees growing in both Trentino-Alto Adige and Ferrara-Mantova districts.

Starch: Baldacci *et al.* (1) reported that roots of trees with moria gave a negative starch reaction while there was an accumulation of starch above the graft union. They suggested that this may be the result of phloem necrosis. Similarly, Batjer and Schneider (2) reported that trees affected by pear decline in Washington consistently had an accumulation of starch above the graft union and a depletion below. Critical starch determinations in trees affected with moria were not made in the present study.

Epidemiology

A report by Mader (8), and observations by Catoni (7), suggest that moria was present in Trentino-Alto Adige as early as 1908. However, it did not reach a serious level until the years 1944-47. The percentage of trees affected in the area during the epidemic varied widely among orchards. Baldacci *et al.* (1) reported typical figures of 3%, 14%, and 28% to 35% in the first, second and third years, respectively. There was no definite pattern of spread in any of the orchards studied. Following the severe epidemic, only a few scattered cases of moria were found. Although moria was reported to occur only in Trentino-Alto Adige (1), in the present study the disease was also observed in the Province of Mantova (Fig. 1).

During the years the disease was most severe, moria was most frequently found in trees 10 to 40 years of age and was not found on nonbearing young trees. Similarly, in the present survey, most of the trees affected were 10 to 40 years old. One 6-to 8-year-old Bartlett tree was found which had typical symtoms of moria, including brown line at the graft union.

Tree variety did not appear to be related to the occurrence of moria, although some early producing varieties such as Moscatella piccola d'estata and Bartlett may be more susceptible to the disease (1). The Barlett variety was most widely cultivated in the Trentino-Alto Adige district and was the most common variety affected.

The relationship of moria to rootstocks is not clear. Studies in North America (2, 3, 5) indicate that trees on Oriental rootstocks (*Pyrus serotina* Rehd. and *P. ussuriensis* Maxim) are most susceptible to pear decline. However, there is no record of commercial use of these oriental rootstocks in Italy. Studies by Baldacci *et al.* (1) and observations made during the present study indicate that many of the affected trees in Italy were on French rootstocks (presumably *P. communis* L). Exact sources of seed used for rootstocks of pear trees in Italy are not known and need further study.

Trees currently affected by moria take several years to die (1). Several trees were observed near Trento which were severely affected and which were reportedly healthy the previous year.

Etiology

Extensive studies by Refatti (12) and Baldacci *et al.* (1) failed to reveal the cause

An approximately 20-year-old Bartlett pear tree near Trento, Italy, with typical symptoms of moria.

Foliage of Bartlett pear tree in Italy affected by moria showing lack of terminal growth.

of moria. No fungus or bacterium, was found to be associated with the disease. No relationship was demonstrated between the disease and war chemicals such as phosphorous and chlorohydrin, or pesticides containing lead, arsenic, or sulfur. Climatic conditions, cultural practices, water relations and nutrition appeared to have no causal relation to the disease. Diseased trees did not respond to injections of growth regulating materials or 8-hydroxyquinoline sulphate. Results of experiments aimed at transmitting a possible causal virus, either by grafting or by juice inoculations, were negative after two years' observation. Up to this present survey, no research work has been conducted on this disease in Italy since 1949.

The pear psylla (*Psylla pyricola* Foerst.) has been suggested as a possible cause of pear decline (10). According to Dr. Gaetano Bua, Director of the Observatory for Plant Diseases in Bolzano, no serious outbreak of pear psylla was experienced in Trentino-Alto Adige prior to 1952 (personal communication). Now this insect is considered one of the most serious pests of pear trees in the area. Although other species were present, (*Psylla pyri* L.) was the most prevalent one found in 1959 and 1960 surveys of Trentino-Alto Adige (6).

Conclusions

The following similarities were found between the moria disease of pear trees in Italy and pear decline in North America, either by direct observation or from the literature.

Symptoms: a) Slow and quick decline foliar symtoms; b) normal appearing main root structure with lack of feeder roots; c) abnormal red foliage in the summer; d) brown line and phloem necrosis in the graft union bark; e) depletion of starch in roots and accumulation of starch above the graft union.

Epidemiology: a) Sudden outbreak followed by decreased incidence of disease. This is similar to the pattern of pear decline in the State of Washington in recent years. b) Some quick decline at the onset of the disease followed predominately by slow decline in later years. Although there was a high incidence of quick decline in Washington during the early years of disease development, there has been little quick decline in this state in recent years (16). c) Age of affected trees (primarily trees of the 10- to 40-year age group are affected). d) Little or no difference in susceptibility among varieties.

There are no apparent difference between moria in Italy and pear decline in North America. Conclusive proof that the two diseases are the same will lie in a demonstration that both are caused by the same factor or combination of factors. At the present time, however, there is no reason to believe that they are not the same.

Acknowledgments

The authors wish to express appreciation to Professors Elio Baldacci, Elvio Refatti and E. C. Blodgett for their kind assistance and advice; and to Pear Zone No. 1, the California marketing program for quality control, merchandising, and research on canned Bartlett pears, for providing funds to make this study possible.

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Pear Decline—1961

By THOMAS A. SHALLA, Assistant Plant Pathologist,
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The year 1961 produced several dramatic developments in the California pear industry's disastrous encounter with pear decline:

1. The disease spread swiftly—an estimated 1,000,000 trees were affected by the year's end, and many were dead.
2. High prices and other economic effects (mainly in the Sierra mountain areas) testified to the impact of pear decline on the industry.
3. A grower financed research team traveled to Italy where the pear moria disease of that country was related to pear decline and other valuable information was obtained (see separate article in this issue).
4. A possible cause of the disease was found.
5. Concern by growers, scientists and government officials continued, and, as funds became available, the research program to find the answers to pear decline went into high gear.

Incidence and Occurrence in California [1]

The incidence of pear decline was greatly increased in 1961 over 1960. El Dorado and Placer counties were the hardest hit, by far. At the other end of the damage scale, Lake and Mendocino Counties still reported comparatively little disease.

Estimated numbers of trees affected by pear decline in the various counties as of July, 1961, were:

County	*Number of diseased trees*
El Dorado	380,000
Placer	105,000
Solano	56,000
Napa	38,500
Sacramento	21,000
Santa Clara	13,100
Nevada	10,000
Yuba	6,000
San Benito	3,500
Glenn	600
Mendocino	400
Sonoma	300
Lake	150

Many more trees were killed or became diseased later in the season after these figures were compiled. Also, no figures were compiled for Yolo, San Joaquin, Tuolumne, Contra Costa, and Santa Cruz Counties where some pear decline was seen prior to and during 1961. Pear decline was recognized for the first time in 1961 in Humboldt, Shasta, Tehama, Butte, Stanislaus, Tulare, Ventura, Monterey, San Luis Obispo, San Diego, and possibly Los Angeles counties. The presence of the disease in the latter county is still questionable. No pear decline was found at Tehachapi (Kern County).

What lies ahead? Have we reached a peak, or can we expect larger numbers of trees to decline in 1962? Things cannot become much worse in the Sierra mountain districts, which possibly have reached their

[1] Data concerning the incidence and occurrence of pear decline in California was collected in cooperation with the County Farm Advisors and County Agricultural Commissioners.

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Two pear decline-affected (right-foreground and center-background) and one apparently normal (left-foreground) pear trees at the University of California Campus at Davis. (Photo by L. R. McKinnon, Dept. of Pomology, University of California, Davis.)

peak. But districts which have not been seriously affected—Lake and Mendocino Counties especially—still have much to lose. Between these extremes lie Sacramento, Solano, Santa Clara and other counties which have incurred great losses but still have most of their pear acreage intact. It is impossible to say how much more damage will occur. The answer depends on (1) the number of remaining rootstocks which are susceptible, (2) the presence of casual agents and (3) the degree to which local climate and other environment factors favor development of the disease. Since the answer to none of these questions is known for certain, the answer to what lies ahead is, at best, an educated guess.

Pear Psylla as a Possible Cause

Late in the year, research workers in the states of Washington and Oregon produced evidence that pear decline is caused by a toxic substance introduced into the tree by the pear psylla while the insect is feeding on it.

According to Washington State University scientists[2] domestic pear varieties, such as Bartlett, were not directly affected by the toxic material but certain pear rootstocks were. The most sensitive rootstocks were the oriental types (e.g. *Pyrus serotina*). The toxic material was transported through the leaves, into the branches and down the trunk to the graft union. At this point sensitive tissues of the rootstock were killed, thereby girdling the tree.

The behavior of the toxic material resembled that of a toxin and not that of a virus. It was heat stable and dialyzable, and

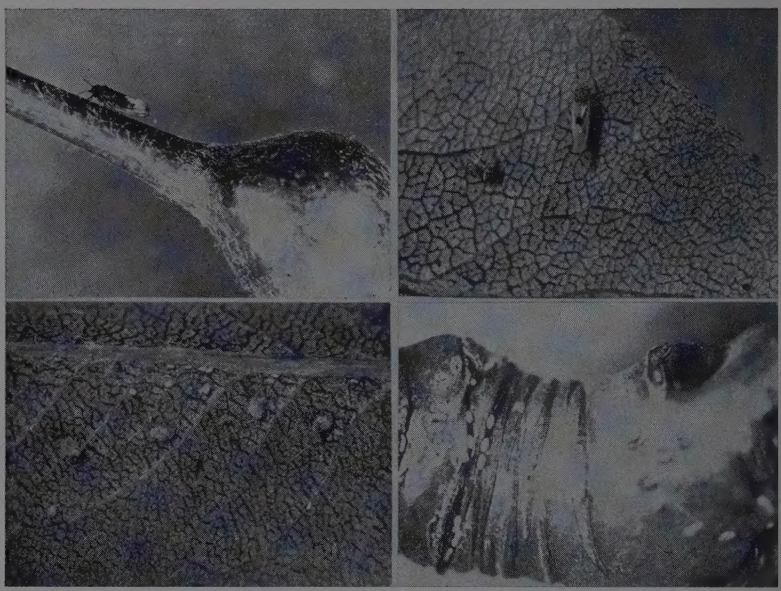
[2] Lindner, R. C., E. C. Burts, and N. R. Benson, 1962. U. S. Dept. Agric. Pl. Dis. Reptr. 46(1):59-60.

Left—Pear shoot showing damage to and sticky exudate (honeydew) left on the foliage by pear psylla feeding on the leaves. Upper right—Adult pear psylla showing wing markings used in identification. Lower right—Nymph or immature stage of the pear psylla. Apparently, this stage produces much more toxin than the adult stage. (Photos courtesy of Sacto. Bee.)

its damage to tissues was proportional to the number of psylla allowed to feed on the test trees. Most viruses are not heat stable and not dialysable. Normally a virus, which increases inside the plant, would ultimately produce the same amount of damage whether it is inoculated into the plant by one insect or many.

According to the Washington scientists, the ability of the toxin to kill was enhanced by high temperatures and other factors which put stress on the tree.

Further work is needed before the toxin theory can be completely accepted. Thus far the disease has been reproduced only in young trees in a greenhouse. It needs to be shown that the pear psylla can cause decline in large bearing trees. Also, certain discrepancies must be resolved including: (1) the occurrence of pear decline in California counties where pear psylla has never been reported; (2) the low incidence of pear decline in Lake and Mendocino Counties, the first psylla-infested counties in California with a considerable amount of commercial pear acreage; and (3) the known occurrence of pear psylla for many years in eastern states where pear decline has never been reported. However, these points may not be insurmountable and continuing investigations in California and elsewhere may augment the Washington evidence and confirm the conclusion that pear decline is caused by a pear psylla toxin.



Pear Psylla: Upper left—Adult psylla on the stem of a young pear fruit. Upper right—An adult and a nymph psylla feeding on a pear leaf. Lower left—Several psylla nymphs feeding on a pear leaf with psylla eggs apparent along the leaf midrib. Lower right—Psylla eggs along the scale scars of a pear fruiting spur. (Photos courtesy of Cornell Univ.)

Control

The new evidence that psylla may be the cause of pear decline raises fundamental questions about control of the disease. In the light of all available information, consideration should be given to the following three points:

1. Use of resistant rootstocks.
2. Good psylla control.
3. Good orchard management to reduce stress and promote vigorous growth.

The last two points apply to pear growing whether or not pear decline enters the picture. However, what was previously considered to be "good" psylla control or "good" orchard management may not be good enough from now on. In order to be competitive in the face of pear decline, growers will need to apply the best possible means of irrigation, fertilization, pruning and training, insect and disease control, and other aspects of orchard practice.

Because of pear decline, research groups in North America and Europe are uncovering new knowledge in all phases of pear growing. This information would have been much longer in coming without the pressures attendant upon the epidemics of pear decline. This situation can only lead to greater future health for all of the pear industry.

The Japanese Beetle In Sacramento

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California Department of Agriculture

The Japanese beetle, *Popillia japonica*, familiar in the Eastern United States as a scourge of lawns, many fruits and vegetables, field crops, vineyards and ornamental plantings, was found in Sacramento on June 7, 1961. The discovery was unique in that it was made by an alert entomologist of the California Department of Agriculture as he walked through Capitol Park on his return from lunch.

The discovery prompted the immediate placement of a number of Japanese beetle traps in the park. Within a few hours, visual inspection resulted in the taking of 14 additional beetles in and around the initial collection site, thus confirming the fear that there was an established infestation.

The Japanese beetle has a long history in the United States. It was first found in New Jersey in 1916 but some authorities believe it was introduced into the United States at an earlier date, possibly before the adoption of the Federal Plant Pest Act of 1912. Since 1916 it has multiplied and spread to the extent that today it is known to exist in 21 states and the District of Columbia with the most western infestation in Missouri.

The Sacramento infestation was the first ever known in California. Accordingly, it was given priority attention by government agencies responsible for quarantine and regulatory pest control measures. The Bureau of Entomology, California Department of Agriculture, was charged with the responsibility of formulating plans to organize and conduct an immediate campaign to eradicate the pest from California.

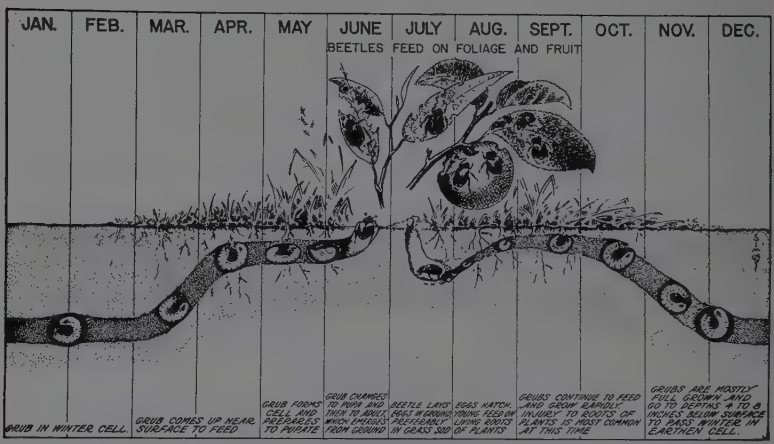
One of the first steps was to organize an intensive trapping and visual inspection campaign to delimit the infestation and determine the area to be treated and placed under quarantine restriction. This required traps.

To augment the 150 traps on hand in Sacramento, the United States Department of Agriculture shipped 650 from Oregon and arrangements were made to receive another 2,000 traps within a few days. Plans were made for trap surveys extending out from the City of Sacramento over an area approximately 50 miles in diameter. Within this area an intensive survey zone composed of Sacramento County and eastern Yolo County was set up. All immediately available traps were placed in Capitol Park and other likely spots throughout Sacramento City and eastern Yolo County. Intensive trapping was carried on in this area until September.

At the height of the season 2,935 traps were placed in the Sacramento-East Yolo area. Four hundred traps were placed in outlying areas, including the Counties of Amador, Contra Costa, El Dorado, Napa, Placer, San Joaquin, Solano, Sutter and Yuba. No beetles were trapped outside the central infested area except for two remote finds. One beetle was taken at the main entrance to Mather Air Force Base, 14 miles east of Sacramento. Bureau entomologists considered it to be a hitchhiker and not related to the Sacramento city infestation. The second exception consisted of three beetles trapped in Citrus Heights, 12 miles northeast of Sacramento. This find proved to be a hoax. The three beetles, all dead, were later found to have been planted in the trap. The condition of the beetle taken at Mather Air Force Base led bureau entomologists to suspect that it also was planted.

Visual inspections, with emphasis on rose blossoms which proved highly attractive to the beetle, were carried on throughout the summer. Actually more beetles were taken in this manner than were recorded from trap catches. Treatment activities were, of course, basic to the eradication campaign. Many problems were presented by this phase of the program.

Arbitrary areas within one-half mile radius of all known infestations were selected as a basis for foliage spray treatment. With Capitol Park the apparent center of infestation, an area of approximately 250 city blocks was initially involved. Later an in-


JAN.
FEB.
MAR.
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BEETLES FEED ON FOLIAGE AND FRUIT
GRUB IN WINTER CELL.
GRUB COMES UP NEAR SURFACE TO FEED
GRUB FORMS CELL AND PREPARES TO PUPATE
GRUB CHANGES TO PUPA AND THEN TO ADULT WHICH EMERGES FROM GROUND
BEETLE LAYS EGGS IN GROUND PREFERABLY IN GRASS SOD
EGGS HATCH YOUNG FEED ON LIVING ROOTS OF PLANTS
GRUBS CONTINUE TO FEED AND GROW RAPIDLY INJURY TO ROOTS OF PLANTS IS MOST COMMON AT THIS TIME
GRUBS ARE MOSTLY FULL GROWN AND GO TO DEPTHS 4 TO 6 INCHES BELOW SURFACE TO PASS WINTER IN EARTHEN CELL.

Chart depicting life cycle of Japanese beetle.

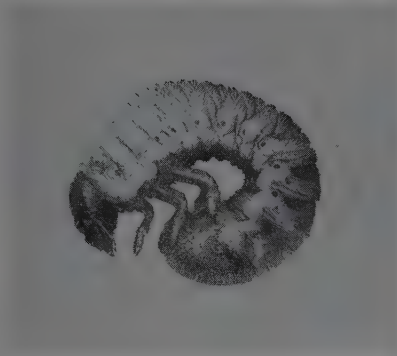
festation, even heavier than in Capitol Park, was found in the city southwest of the park which necessitated adding another 50 blocks to the foliage treatment area. An average downtown block in Sacramento covers approximately three acres. Thus, nearly 1,000 acres were estimated to be included in the treatment area.

Later in the season several single adult beetles were taken from roses by homeowners in outlying areas. One was in West Sacramento approximately one and one-half miles from the Capitol Park area. Another was found one-half mile east of the downtown area of Sacramento. Accordingly, a one block border around each find was included in the treatment area, thus adding about 20 blocks, or 60 additional acres, to the treatment area. Residences and other buildings in the area reduced the actual acreage by an estimated one-third, but huge shade trees in the area offset this reduction because of their foliage which required spray treatment.

The insecticide Sevin was used since experience in the eastern part of the United States proved it to be the best known material for foliage sprays aimed at eradicating the Japanese beetle. Sevin was reported to be very effective and fast acting, and had the added advantages of very low phytotoxicity on plants and an exceptionally low toxicity to all forms of wildlife and humans.

As a result of the foliage spray program, several complaints were received from yard owners concerned by damage to flowers and shrubs thought to be caused by the spraying. Subsequent investigations by department plant experts showed plant and shrub damage was not caused by Sevin spray. Unusually hot weather in June and July caused burning to a number of plants in the sprayed area. Plant pathologists in the department determined some of the plant collapse to be due to excessive watering which killed many feeder roots. Along with high temperatures in the early summer of 1961, there was also a heavy mite infestation. Both inside and out of the control area spider mites, probably stimulated by the early heat, developed tremendous populations, and many backyard vegetable gardens and deciduous fruit and nut trees were nearly defoliated. No evidence could be found to substantiate the theory that there was spray damage.

The foliage spray plan presented several problems. One was spray equipment, since the department had only one small hydraulic spray rig available in Sacramento when the first beetle was found. As a result, all department projects throughout the State employing spray equipment, were called upon to rush any rigs that could be spared to the Sacramento project. Within a week two Buffalo turbine sprayers from



Japanese beetle grub or larva.

the bureau's Beet Leafhopper project in the Lower San Joaquin Valley, were in Sacramento and together with the available hydraulic sprayer were put into service on June 13.

A second problem was foliage spray concentrations. After several trials, 20 pounds of Sevin in 100 gallons of spray were used in the Buffalo turbines. One pound of Sevin in 100 gallons of water was used in the hydraulic sprayers.

By June 16 one 300-gallon capacity hydraulic and four 150-gallon sprayers, in addition to the two turbine sprayers, were in service.

Trees in the area required high volumes of spray which made progress painfully slow and inadequate. Some of the spray rigs were only capable of 7 to 10 gallons per minute, and the largest hydraulic sprayers had a maximum capacity of 35 gallons per minute. It was felt that in order to adequately cover the large trees in a satisfactory period of time with conventional hydraulic sprayers, spray rigs with a 50-gallon per minute capacity, operating at high pressures, would be needed.

Also, since satisfactory foliage coverage with this type equipment would require very high pressures and volumes of spray which would, in turn, leave yards in a wet, sloppy condition, and would also harm flowers, vegetables and low shrubbery planted in most of the residential yards of the area, it seemed advisable to resort to mist sprays or to dusts. The use of mist type spray equipment eventually solved this problem. The Sacramento County Road Department had one mist type sprayer which was loaned to the department for trials to determine if mist sprays would prove satisfactory in controlling the Japanese beetle. These trial tests proved mist sprays to be ideally suited for the program.

In downtown Sacramento, where the infestation was centered, the street plan includes alleys through the center of almost every block. This situation enabled spray crews to reach all the trees in the area with a minimum of difficulty. By operating from the streets and these alleys all trees and foliage were sprayed, above a height of approximately 15 feet, with a low volume, high concentration of Sevin spray applied by mist sprayer. Fifty pounds of Sevin in 100 gallons of water was the formula selected for mist spraying.

Conventional sprayers operating at low volumes and pressures, were used on lawns, shrubs and the lower parts of trees. Spraying time was reduced by nearly 50 percent when mist sprayers were so used in conjunction with the conventional type spray rigs.

After one week of spray operation it was apparent that the eradication program to operate effectively would require several additional spray rigs of both the conventional and mist spray type. Consequently two mist sprayers were purchased, one a 100 gallon tank machine capable of putting

Japanese beetle adult.

Cluster of Japanese beetle adults on peach.

Damage to turf by Japanese beetle grubs.

Japanese beetle adults damaging field corn.

out 10 gallons per minute at high pressure in an air stream of 28,000 cubic feet per minute and the other, a 300 gallon rig with the same capacity and a 60,000 cubic foot per minute rating. In addition, two hydraulic 500 gallon tank, 35 gallon per minute, spray rigs and two trucks upon which to mount the hydraulics were ordered. The order was placed on June 27 and through the co-ordination and co-operation of the department fiscal office and the State Department of Finance, some of the equipment was in operation by July 7. Next the department contracted with the City of Sacramento to furnish two power dusters with personnel to operate them. These units were used to dust trees along the streets of the treatment area using a 10 percent Sevin dust. Dust rather than a mist spray was selected for this phase of the foilage treatment in order to avoid any chance of liquid spray damage to automobiles parked overnight in front of residences. Dusting was done at night because of traffic conditions during the day.

By mid-July, 12 rigs, including the two city dusters and the Sacramento County mist sprayer, were in operation. This was the maximum number of rigs used during the treatment phase of the program. Four of the spray rigs were only capable of putting out seven gallons of spray per minute, and it was not until the new equipment including both the two mist sprayers and the two 500 gallon tank hydraulics were in operation that satisfactory progress was made and the area could be covered within a 10-day period. Recommendations of entomologists in the east prompted the decision to apply foliage sprays at 10-day intervals throughout the flight season of the beetle. The 10-day interval was based on the residual effectiveness of Sevin and new growth of plants between applications. The use of the two Buffalo turbine sprayers was discontinued when the mist sprayers were put into operation since it was found the mist sprayers did a better job and had sufficient capacity to cover the entire area in the allotted time.

Unlike conditions in the eastern part of the United States, there are a number of factors in California which favor complete eradication of the Japanese beetle. Eradication efforts in the east are complicated by the effects of summer rainfall common in nearly all eastern areas where the beetle has become firmly established and by the constant threat of reinfestation from the many nearby infestations.

Japanese beetle eradication factors listed by the department in the order of probable importance were:

1. No known outlying or nearby infestations from which flight or carryouts could occur, thus preventing reinfestation.

Applying chlordane in 1,000 gallons of water per acre to lawns in Japanese beetle eradication effort.

Crew assembling Japanese beetle traps for use in eradication effort.

Spreading granular chlordane to turf with cyclone seeder in Japanese beetle eradication effort.

Night dusting of street trees in Sacramento for Japanese beetle eradication.

2. California, unlike other Japanese beetle areas, does not have summer rainfall. The Japanese beetle requires 10 inches or more of summer rainfall, or a comparable amount of irrigation water, to thrive. Without several inches of water during the summer months, it is doubtful that the beetle could survive. This is important in the prevention of continued infestation and eliminates the need to treat thousands of dry-farmed acres around Sacramento.
3. Heavy watering, an almost daily practice in the residential areas, provides excellent environment for the beetles to thrive and multiply. While this might appear to be an adverse factor, the converse is true as the beetle grubs would probably be confined to a relatively limited habitat. The luxuriant foliage existing in the residential areas would seem to preclude any widespread flights in search of food.

Because of climatic conditions in California unlike those in other Japanese beetle infested areas it seemed advisable to make a series of tests to determine residual effectiveness of Sevin. Leaf samples, taken at intervals throughout the summer, consisted of 100 leaves taken from around the perimeter of each selected tree or shrub. A few samples were taken from trees or shrubs in different areas of the city but most were taken periodically from the same shrubs and trees.

Test data is summarized in the following eight tests:

Test No. 1 included samples from plants receiving the three types of applications adopted and indicated very satisfactory deposits of insecticide with the possible exception of the dusted tree.

TEST No. 1

Application dates	*Sampling dates*	*Type of plant*	*Application method*	*Sevin found p.p.m.*
June 20 and 30	July 3	Elm tree	10% dust	6
Same	Same	Shrub	Hydraulic spray	100
Same	Same	Wild rose	Same	73
Same	Same	Orange tree	Mist spray	36

To further check residual deposits following dust applications, samples from four street trees were taken in other areas and these samples indicated satisfactory deposits. Those results are shown in Test No. 2.

TEST No. 2

Application dates	*Sampling dates*	*Type of plant*	*Application method*	*Sevin found p.p.m.*
June 20 and 30	July 6	Elm tree	10% dust	92
Same	Same	Same	Same	15
Same	Same	Same	Same	31
Same	Same	Same	Same	35

In order to determine the persistence of Sevin, samples were taken 10 days after the second treatment from three of the four plants sampled in Test No. 1.

Test No. 3 indicated excellent persistence of Sevin, but also pointed out the possibility of residue variation in chance sampling.

TEST No. 3

Application dates	*Sampling dates*	*Type of plant*	*Application method*	*Sevin found p.p.m.*
June 20 and 30	July 10	Tree	10% dust	8
Same	Same	Shrub	Hydraulic spray	267
Same	Same	Tree	Mist spray	119

The fourth test included sampling previously checked plants to determine possible buildup of Sevin following multiple applications. The results indicate that residual life is good and that heavy buildup of Sevin following four applications might be expected under Sacramento conditions.

TEST No. 4

Application dates	*Sampling dates*	*Type of plant*	*Application method*	*Sevin found p.p.m.*
June 20 and 30 July 20 and Aug. 3	August 11	Shrub	Hydraulic spray	375
Same	Same	Tree	Mist spray	240
Same	Same	Tree	10% dust	357

Test No. 5 involved the same plants as in Test No. 4 except that samples were taken one week later than in Test No. 4. This interval was the equivalent of 15 days after the fourth application. Test No. 5 indicated that effective residues persist for over two weeks under Sacramento conditions.

TEST No. 5

Application dates	*Sampling dates*	*Type of plant*	*Application method*	*Sevin found p.p.m.*
June 20 and 30 July 20 and Aug. 3	August 18	Shrub	Hydraulic spray	379
Same	Same	Tree	Mist spray	137
Same	Same	Tree	10% dust	62

Test No. 6 consisted of sampling of the same plants used in Tests 1, 3, 4 and 5. It further proved the excellent residual persistence of Sevin but again indicated considerable variation due to sampling chance.

TEST No. 6

Application dates	*Sampling dates*	*Type of plant*	*Application method*	*Sevin found p.p.m.*
June 20 and 30 July 20 August 3	August 25	Shrub	Hydraulic spray	485
Same	Same	Tree	Mist spray	76
*Same	Same	Tree	10% dust-mist	624

Test No. 7 involved the same plants as in Tests 1, 3, 4, 5 and 6 and indicated residual persistence of Sevin for nearly one month.

TEST No. 7

Application dates	*Sampling dates*	*Type of plant*	*Application method*	*Sevin found p.p.m.*
June 20 and 30 July 20 August 3	Sept. 1	Shrub	Hydraulic spray	237
Same	Same	Tree	Mist spray	84
*Same	Same	Tree	10% dust-mist	107

Test No. 8 involved the same plants sampled in Tests 1, 3, 4, 5, 6 and 7 and indicated satisfactory residual deposits some 40 days after application.

TEST No. 8

Application dates	*Sampling dates*	*Type of plant*	*Application method*	*Sevin found p.p.m.*
June 20 and 30 July 20 August 3	Sept. 11	Shrub	Hydraulic spray	188
Same	Same	Tree	Mist spray	47
*Same	Same	Tree	10% dust-mist	176

* August 3d application mist spray—all others 10% dust.

Foliage test procedure.

Deposits of Sevin on leaves were determined by stripping them with benzene, hydrolyzing to alpha-napthol with 0.5N sodium hydroxide, developing color with p-nitrobenzenediazonium fluoborate and reading the color against a reagent blank at 590 millimicrons.

This series of tests indicated that under Sacramento conditions, with only a trace of rain during the summer season, residual Sevin builds up with each application and that other factors, such as heat, do not appreciably affect the persistence of the insecticide.

It was also evident that dust applications, while resulting in general satisfactory deposits, do not tend to build up deposits as rapidly nor do they persist as long as those from liquid applications.

Once the foliage spray program was organized and progressing normally, the next problem, and perhaps the most important phase of any eradication attempt against Japanese beetle, was the question of soil treatment. While foliage sprays are very important in reducing populations thereby preventing spread as well as egg deposition, entomologists experienced in the control of the beetle emphasize proper soil applications of insecticides to kill the larval or grub form of the insect as the most effective measure in a control or eradication program.

Reports from research entomologists indicate that soil treatments, particularly those applied later than June or July, will not prevent considerable emergence of adult beetles the following spring, but that eventually they are effective to a high degree. This lag is probably due to the fact that

Mist sprayer applying high concentrate foliage sprays in Japanese beetle eradication.

initial soil treatments applied late in the season fail to achieve 100 percent effect on advanced stage instars of grubs already in the ground. Grubs from later egg deposits in soil previously treated are very susceptible to the insecticide. Some authorities attribute this delayed effectiveness to poor distribution of the insecticide in the soil during the first several months. Therefore, it was deemed important to apply insecticides so that the best possible initial distribution could be attained thus possibly approaching 100 percent control the first season.

It followed then that the real problems in soil treatment were the determination not only of the most effective insecticide to use but the best application method to insure rapid penetration and diffusion in the soil.

In the eastern United States, small amounts of DDT or chlordane proved to be superior to lead arsenate originally used for control or suppression of the beetle. Eastern records of subsequent treatments with DDT did not show it to be superior to chlordane. In fact lesser amounts of chlordane were required to achieve even better control. In later years dieldrin, aldrin and, more recently, endrin, showed great promise. Endrin in particular appears to be more rapid than other hydrocarbons in its action against the beetle grubs. However, it is an extremely toxic material and possibly hazardous to humans and pets if used in residential areas.

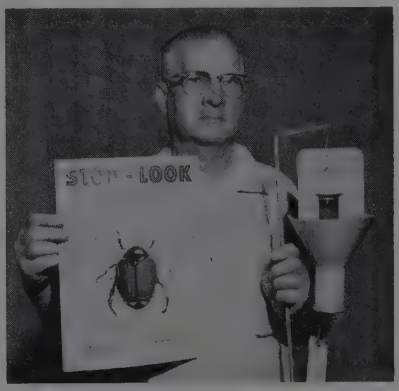
In California chlordane is a commonly used insecticide, is effective against Japanese beetle for periods up to 12 generations, is less toxic than aldrin, dieldrin or endrin and has good public acceptance with respect to concern over health hazards.

Where chlordane has been used in Japanese beetle soil treatment areas of the east no significant difference in control has been observed regardless of the chlordane formulation or method of application. It has proven effective when applied as a dust, granular formulations, wettable powders and as emulsion concentrates. Liquid formulations, from 10 to 1,000 gallons per acre, have been applied with devices ranging from sprinkling cans to power sprayers with broom guns. In the east, summer rains are usually depended upon to ultimately drive the insecticide into the soil. In California, although there is little or no summer rain, heavy sprinkling over most turf has the same, and possibly a greater effect, than natural rainfall.

In Sacramento the goal being eradication rather than control, it was felt that every effort should be made to get as much of the insecticide as possible into the soil, as rapidly as possible.

Many entomologists disagree with conclusions drawn from insecticide recovery rates as determined by chemical analysis of soil samples. Some feel that techniques of soil sampling might lead to errors while recovery rates determined by bio-assay in some instances have not agreed with rates determined by chemical analysis.

Despite these handicaps it was decided, in this instance, with the available help of the Department's Division of Chemistry, to analyze soil samples from plots treated by



Lester Jensen, U.S.D.A., Plant Pest Control District Inspector, showing completely assembled Japanese beetle trap and U.S.D.A. poster distributed throughout the eradication area.

various methods in order to determine the best method for soil treatment. The decision was influenced by the fact that the Sacramento area has hot, dry summers and a long-growing season. Also, since insecticide residue persistence above ground was known to be exceptionally good, it raised the question of how much would go into the soil.

Test plots containing about 500 square feet were set out. Ten random soil samples two inches in diameter and three inches in depth were selected from each plot.

All grass and debris above the soil surface were removed before sampling in order that analysis would indicate only the amounts of insecticide available to grubs in the soil.

According to one eastern authority * 0.44 pounds per acre of chlordane remaining in the top three inches of soil resulted in 100 percent control of Japanese beetle grubs. However, it is doubtful if an initial recovery at this rate would be effective against first generation grubs particularly if application was made to late instars in late summer. Many reports indicate that applications made later than June were not entirely effective against the over-wintering grubs. Polivka (1960) reported 100 percent control of first generations following the application of five pounds of chlordane per acre as late as July. However, he does not in this instance, report the amount of initial or subsequent recovery of the insecticide.

With few exceptions, samples consisted of the top three inches of soil. For a standard, the top three inches of soil over an acre was considered to weigh one million pounds. Recovery rates expressed in p.p.m. are therefore the equivalent of pounds per acre. With few exceptions test applications were made at the rate of 10 pounds of chlordane per acre.

In soil test No. 1 sprays were applied with a Hudson sprayer at the rate of 25 gallons per acre. Dust was applied with a hand duster at the rate of 100 pounds of a 10 percent dust per acre. All materials were watered in with a power spray rig.

* Polivka, J. B. 1960—Small Amounts of Insecticides Effective in Controlling Grubs of the Japanese Beetle—Jour. Econ. Ent. 53(2) 320.

SOIL TEST No. 1

Application date	*Sampling date*	*Formulation*	*Terrain*	*Chlordane recovered p.p.m.*
7/5/61	7/7/61	Emulsifiable	Bare ground	35.0
		Same	Heavy lawn	0.5
		40% wettable powder	Heavy lawn	0.3
		Dust		1.0

Soil Test No. 1 indicated a puddling of the insecticide and *improper sampling of the bare ground*. There appeared to be a better penetration in lawns with dusts rather than with sprays. It was, however, determined that dusts could not be satisfactorily controlled or evenly distributed under existing conditions. Therefore, no further trials were made with dusts.

Soil Test No. 2 consisted of sprays applied with a power sprayer using a broom gun with T jet nozzles. The application was made at the rate of 100 gallons per acre using 100 pounds pressure. In some cases a wetting agent was used. In all cases the insecticide was watered-in. The grass was carefully removed and analyzed separately from the three inches of soil.

SOIL TEST No. 2

Application date	*Sampling date*	*Formulation*	*Terrain*	*Wetting agent*	*Chlordane recovered p.p.m.*	
					Grass	*soil*
7/13	7/17	Emulsifiable	Heavy turf	—	115	0.68
		Wettable powder	Same	—	15	0.59
		Wettable powder	Light turf	—	51	0.60
7/14	7/17	Emulsifiable	Heavy turf	1 gal. to 100	140	1.2
		Emulsifiable	Same	5 oz. to 100	194	0.78
		Emulsifiable	Same	—	91	0.41
		Emulsifiable	Same	—	61	0.44

The wetting agent was added in an attempt to get more of the insecticide immediately into the soil by keeping the insecticide from adhering to the grass. For undetermined reasons, recovery rates were higher from both the grass and the soil where a wetting agent was added.

Soil Test No. 3 consisted of using emulsifiable chlordane applied with a power sprayer. The spray was applied on heavy lawn growth at 10 pounds per acre in 200 gallons of water, a wand or broom type gun with T jet nozzles at 300 pounds pressure was used and the application was watered-in.

SOIL TEST No. 3

Application date	*Sampling date*	*Wetting agent*	*Chlordane recovered p.p.m.*	
			Grass	*soil*
7/18	7/19	No	184.0	6.00
		6 oz. to 100 gals.	76.0	1.3
		1 gal. to 100 gals.	134.0	1.7

Recovery rates in this test were very satisfactory indicating that higher pressures resulted in increased amounts penetrating into the soil but also indicating that wetting agents were of no value in improving this penetration.

In the Sacramento residential area it was found that the broom type guns were difficult to operate effectively around ornamental plantings. Consequently in Test No. 4 a conventional bean spray gun was used to determine its effectiveness. The wetting agent and watering-in factors were also tested. Ten pounds of chlordane, by weight, in emulsified form, was applied at the rate of 200 gallons per acre and 200 pounds pressure. The test was made on a well established lawn.

SOIL TEST No. 4

Application date	*Sampling date*	*Wetting agent*	*Watered-in*	*Chlordane recovered p.p.m.*
7/24	7/26	No	Yes	0.92
		2 qt/100	Yes	0.60
		No	No	0.20
		2 qt/100	No	0.34
		1 gal/100	No	0.53

Test No. 4 indicated that the conventional spray gun gave satisfactory insecticidal deposits. It further indicated the wetting agent to be of no value, and that watering-in was necessary at the volumes and pressures employed.

Soil Test No. 5 consisted of analyzing samples from the top three inches of soil from an area given a regular field treatment. The soil had been sprayed with emulsifiable chlordane at 10 pounds in 200 gallons per acre at 200 pounds pressure. The equipment consisted of a power sprayer with broom gun. The spray was watered-in.

SOIL TEST No. 5

Application date	*Sampling date*	*Chlordane recovered p.p.m.*
7/21	8/3	0.52

The results of the test indicated the chlordane recovery somewhat lower than could be desired.

Soil Test No. 6 consisted of samples from a field treated with granular chlordane applied with a cyclone seeder and watered-in.

SOIL TEST No. 6

Application date	*Sampling date*	*Chlordane recovered p.p.m.*
7/24	8/3	0.37

Recovery rate was low but inconclusive due to inaccurate calibration which resulted in an application of only seven and one-half pounds of chlordane per acre.

In Test No. 7 samples of the top three inches of soil were taken from parking strip lawns where live Japanese beetle grubs were found on August 4. The lawns had been treated with emulsifiable chlordane at 10 pounds per acre using a power sprayer applying 200 gallons per acre at approximately 200 pounds pressure with a broom gun. The chlordane had been watered-in.

SOIL TEST No. 7

Application date	*Sampling date*	*Chlordane recovered p.p.m.*
7/25	8/7	0.87
7/25	8/7	0.84

Samples from Test No. 7 indicated that field treatments resulted in satisfactory soil concentrations of chlordane and further pointed out, as in previous tests, that watering-in at volumes and pressures employed was necessary requiring the use of a second spray rig.

Test No. 8 consisted of an analysis of the top three inches of soil that had been treated with emulsifiable chlordane at 10 pounds per acre using various gallonages with and without wetting agents. Equipment consisted of a power rig and conventional spray gun. Application was made at 200 pounds pressure with and without watering-in.

SOIL TEST No. 8

Application date	*Sampling date*	*Gallons per acre*	*Wetting agent*	*Watered-in*	*Chlordane recovered p.p.m.*
7/24	8/4	400	No	Yes	3.0
7/25	7/26	400	No	Yes	3.20
		400	No	Yes	0.73
		400	No	No	0.59
		400	2 qt/100	Yes	0.73
		400	No	Yes	3.20
		600	No	No	0.37

Test No. 8 further indicated that satisfactory results with conventional spray guns could be expected. Wetting agents apparently were of no value and watering-in was necessary at volumes up to 600 gallons per acre.

Test No. 9 was made to determine the effectiveness of different gallonages applied with power spray rigs and conventional spray guns, using pressures of 50, 200 and 250 pounds with and without watering-in.

SOIL TEST No. 9

Application date	*Sampling date*	*Gallons per acre*	*Pressure*	*Watered-in*	*Chlordane recovered p.p.m.*
8/1	8/4	400	200	Yes	0.68
8/2	Same	400	200	Yes	1.00
8/2	Same	1,000	200	Yes	0.93
8/2	Same	1,000	200	No	0.77
8/4	8/7	1,000	50	No	0.51
8/8	8/30	1,000	250	No	1.39

This test indicated satisfactory recovery with applications of 1,000 gallons per acre without the necessity of watering-in. It also indicated that higher pressures were more desirable where watering-in was not practiced. Thus by applying 1,000 gallons per acre at pressures slightly in excess of 200 pounds using conventional spray guns, satisfactory results could be achieved without the necessity of the time consuming watering-in process.

Test No. 10 was a check on the accepted field treatment technique following application of 10 pounds chlordane per acre in heavy lawn areas. The top three inches of soil was sampled.

SOIL TEST No. 10

Application date	*Sampling date*	*Formulation*	*Gallons per acre*	*Equipment*	*Chlordane recovered p.p.m.*
August 11	August 14	Emulsifiable	1,000	Bean gun	3.4
Same	Same	Same	Same	Same	1.4

Test No. 10 substantiated the adopted field treatment procedure. As a consequence this method of liquid application was continued throughout the remainder of the season.

Soil Test No. 11 involved soil samples from heavy lawn areas subjected to regular field treatments at the 1,000 gallon per acre liquid application or 100 pound per acre application of 10 percent chlordane granules. This test differed from previous tests in that profile samples of the top three inches of soil were taken to determine the diffusion of chlordane throughout the top three inches of soil.

SOIL TEST No. 11

Application date	*Sampling date*	*Formulation*	*Chlordane recovered p.p.m.*
August 11	August 25	Liquid	
		Top inch	13.6
		2d inch	2.4
		3d inch	1.6
		Granular	
		Top inch	1.7
		2d inch	0.57
		3d inch	0.88

Test No. 11 indicated that diffusion was satisfactory and initial recovery with liquid applications was higher than with granular applications. Less insecticide should be fixed on the grass with granular application than with liquid so it is quite possible that recovery from granular application as it worked through the surface debris into the soil would eventually equal or perhaps surpass that from the liquid application.

Soil Test No. 12 consisted of additional profile samples taken from field areas treated on August 30, 22 days after liquid application and eight days after granular application of chlordane.

SOIL TEST No. 12

Application date	*Sampling date*	*Formulation*	*Chlordane recovered p.p.m.*
August 8	August 30	Liquid	
		Top inch	2.74
		2d inch	0.84
		3d inch	0.61
August 22	August 30	Granular	
		Top inch	3.13
		2d inch	0.68
		3d inch	0.54

This test indicates that in well watered areas, after a period of a week or more, insecticide recovery with granular application compares favorably with the 1,000 gallon per acre liquid application.

Near the end of the treatment season, following the regular soil treatment at 10 pounds of chlordane per acre, all areas near adult Japanese beetle finds received an additional granular application of five pounds per acre in order to increase the chlordane in the soil.

Test No. 13 was conducted to evaluate the effectiveness of the additional five pounds of chlordane added, and to determine any changes in diffusion over the two-month period following the last applications.

SOIL TEST No. 13

Initial application	*Second application*	*Sampling date*	*Formulation*	*Chlordane recovered p.p.m.*
July 26	August 30	October 26	Liquid-granular	
			Top inch	0.91
			2d inch	1.46
			3d inch	0.53
August 22	September 11	October 26	Granular	
			Top inch	1.36
			2d inch	0.44
			3d inch	0.25

Results of Test No. 13 were somewhat disappointing since the rate recovered was considerably less at most levels than found in the test made before the additional five pounds per acre granular application was made.

Soil samples next were taken from a treated area in the eastern part of Sacramento but evidently large amounts of toxaphene had been used on elm trees in that particular area and concentrations were so high in the soil that the chlordane was masked and the chemists were unable to determine the amount of chlordane in the soil. This area had received a single treatment with 10 pounds of actual chlordane in 1,000 gallons of water per acre and to compare the recovery rate with areas having received 15 pounds of granular chlordane, further samples were taken in the same general area but one or two blocks removed from the original sampling point. This attempt was only partially successful as the elm trees in several blocks in that part of the city had been sprayed with toxaphene by city

crews, resulting in a very heavy deposit of toxaphene in the soil. Over nine p.p.m. of toxaphene in the top three inches of soil were recovered in this second sampling and the chemists were able to determine only the approximate amount of chlordane.

Test No. 14 was conducted to determine the amounts of chlordane that could be recovered from the top three inches of soil having received one liquid application of 10 pounds actual in 1,000 gallons of spray applied at pressures of 200 to 250 pounds per square inch with a power sprayer and where 15 pounds of actual chlordane to the acre were applied with a cyclone hand seeder in two applications, the first at the 10-pound rate, the second at five pounds.

SOIL TEST No. 14

Initial application	*Second application*	*Sampling date*	*Application*	*Chlordane recovered p.p.m.*
August 14		November 9	Liquid	1 to 2 *
August 24	September 11	November 9	10% granular	1.93

* Difficult to determine exact amount because of the interference of toxaphene.

This test indicated that either method of application was satisfactory but because of the toxaphene interference added little to our knowledge concerning the respective merits of liquid versus granular application or what additional chlordane recovery might be expected following the application of the additional five pounds per acre.

In an attempt to determine what happened to the chlordane in excess of the amount recovered, samples of the debris from the surface of the soil were taken from the same area as that having received the two granular treatments as above. In taking the samples the green blades of grass were carefully removed and discarded, all remaining debris down to the actual soil surface being included in the samples.

SOIL TEST No. 15

Initial application	*Second application*	*Sampling date*	*Chlordane recovered p.p.m.*
August 24	September 11	November 14	152.0

This test indicated that a rather high percentage of chlordane is present in the debris at the soil surface some of which may eventually be washed into the soil.

In a further attempt to determine what became of the chlordane over and above the amounts recovered in the top three inches of soil, square foot samples were carefully taken, including the grass, surface debris and the top three inches of soil from an area having received an application of 10 pounds of liquid chlordane per acre; an area receiving 10 pounds of liquid chlordane plus five pounds of granular chlordane per acre, and an area receiving 15 pounds of granular chlordane per acre.

SOIL TEST No. 16

Initial application	*Second application*	*Sampling date*	*Formulation*	*Pounds per acre*	*Chlordane recovered Pounds per acre*
August 24	September 11	December 7	Granular	15	6.53
August 11		December 7	1,000 gallons liquid	10	4.79
July 26	September 7	December 7	200 gallons liquid-granular	15	1.92

This test showed fairly satisfactory and probably effective amounts of chlordane recovery with the possible exception of the liquid application, followed by the added five pounds of granular chlordane. Probably some chlordane was lost in all areas by removal of lawn clippings, by volatilization and by penetration beyond the three-inch level, but nevertheless the percentage loss seemed rather high. The grass and surface debris in the samples probably weighed far less than 10 percent of the total weight, but even at that rate, if the chlordane was fairly evenly distributed between the grass debris and soil, the sample with the lowest recovery rate showed a possible yield of nearly 1¾ pounds per acre in the top three inches of soil.

An additional and final test of the season was made to further clarify the picture regarding chlordane distribution. The grass and surface debris was carefully removed from one square foot areas immediately adjacent to the square foot samples analyzed in Test No. 16 and several two-inch plugs of soil, three inches deep, were taken from each of these areas.

SOIL TEST No. 17

Initial application	*Second application*	*Sampling date*	*Formulation*	*Pounds per acre*	*Chlordane recovered p.p.m.*
August 24	September 11	December 18	Granular	15	1.3
August 11		December 18	1,000 gallons liquid	10	2.1
July 26	September 7	December 18	200 gallons liquid-granular	15	1.6

Amounts of chlordane recovered from the top three inches of soil in this test were very satisfactory, approaching in the area with the lowest recovery rate in the previous test, the 1¾ pounds suggested possible. It is interesting to note that the sample with the highest recovery rate in Test No. 16 in this test showed the lowest rate in the top three inches of soil and further that the chlordane recovery from the single 10-pound application exceeded amounts from the areas having received 15 pounds per acre.

At any rate the season's work has been completed. We believe the foliage sprays to have been so effective that there was little chance of spread by carry-out or by flight after late June. It will indeed be fortunate if prior to that time there was no carry-out to untreated areas other than the single beetles found at 27th Street in Sacrameno and in West Sacramento.

We believe the treatment area covered a large enough area to control any spread by normal flight which, because of favorable factors listed earlier, were probably limited. Hitchhikers in cars could have been transported considerable distances and should gravid females or pairs of beetles been so transported survey during the next season may reveal incipient infestations beyond the treatment area.

We hope that the foliage sprays and soil treatments so reduced populations of adults and grubs that spring emergence will be light and further spread will be prevented by early foliage sprays. Intensive trapping and visual inspections in the spring of 1962 should provide the answer as to whether these beliefs and hopes are justified.

Soil test procedure.

Deposits of dieldrin and chlordane on grass and in soil were determined by stripping with petroleum ether and measuring the amounts on a microcoulometric gas chromatograph. The extracts from the grass were cleaned up with a florisil column before putting them through the chromatograph.

New Emphasis on Solids-Not-Fat Component of Milk

By L. C. SCHAFER
Chief, Bureau of Milk Stabilization
California Department of Agriculture

The market place is like a kaleidoscope. Consumer demands present a varied and constantly changing picture. Of all the commodities that flow into the market place, food items are perhaps the most stable. However, changes in dietary habits are causing changes in the demands for food commodities.

One such change is taking place in the marketing of dairy products.

A shift is taking place in the relative demand, and thus the relative value, of the milk-fat and solids-not-fat (SNF) components of milk.

In California, this shift can be measured in the per capita consumption of milk, skim milk and cream. The following table shows this trend:

PER CAPITA CONSUMPTION, CALIFORNIA

	(quarts)		
Year	*Milk*	*Skim milk*	*Cream*
1950	124.70	2.79	1.42
1955	130.30	5.05	1.03
1960	126.05	7.79	1.00

The per capita consumption of skim milk, or nonfat milk, demonstrates the increased demand for the SNF component of milk. The demand for cream and dairy products with a high proportion of milk fat has decreased.

The present trend in the market for dairy products is placing a relatively greater demand upon SNF and a lesser demand for the milk fat component of milk.

In this environment of change, representatives of the dairy industry for both producer and distributor groups prevailed upon the 1961 session of the California Legislature to enact a bill which would facilitate adjustment to this trend. As a result, Assembly Bill 2742 was passed and became effective in September, 1961.

Assembly Bill 2742 provides the standards for a new dairy product, "low-fat milk," which is to have a milk-fat content that ranges from 1.9 percent to 2.1 percent, a SNF content of not less than 10 percent. It also provides for the establishment of minimum wholesale and minimum retail prices for this new product.

In connection with low-fat milk, the bill provides that the standards for this product cannot become effective until minimum producer prices are established on the basis of the milk-fat and SNF components of milk and that the section of the bill containing the standards for low-fat milk expires October 1, 1963, unless re-enacted.

The bill provides for pricing milk received from dairy farmers on the basis of the milk-fat and SNF components of milk, and for testing to determine the SNF content of the milk.

This bill, although only four pages long, calls for a complete overhaul of the producer pricing system and creates a new dairy product for California consumers.

The bill was assigned to the Director of Agriculture to administer.

In response to his obligations under the new legislation, the Director of Agriculture has designated the Bureau of Dairy Service to administer the testing of the milk for SNF, the licensing of the testers and the certification for accuracy of the testing equipment. The Bureau of Dairy Service has held a rules and regulations hearing and will issue rules and regulations to achieve this purpose.

The Director has assigned the task of creating a new pricing procedure for producer prices and establishing minimum prices for low-fat milk to the Bureau of Milk Stabilization.

An objective of marketing low-fat milk is to increase the total sales of dairy products and not merely provide a new dairy product to displace sales of regular milk. It is important to market this new product with a minimum of market disruption.

Initially, this product must be priced on a relative cost basis in the absence of actual cost experience in the market. The difference in raw product cost between low-fat milk and regular milk can readily be computed. Under the present minimum producer prices that are established, the raw product cost differential is approximately 3 cents per quart. However, the cost of handling this product, both in the plant and on the routes, will be somewhat higher than regular milk because of the smaller quantities that will be handled. For example, in the filling operation, the runs, or amount of filling time, will be shorter than for regular milk and the filling expense for low-fat milk will probably be more comparable to that for by-products such as skim milk or buttermilk. The expense for handling on the routes would probably be more comparable to the handling expense for by-products than for regular milk. At any rate, the initial cost determination for marketing this product will necessarily be a related cost determination, rather than an actual cost determination.

In establishing the minimum prices for low-fat milk, if these prices are substantially below those of regular milk, there will be a price incentive created that will result in decreased sales of regular milk and the industry will be faced with increased costs of marketing regular milk.

On the other hand, if the minimum prices that are established for this product are set too high, say, for example, at the same prices as regular milk, the margin accruing to distributors would be relatively large, and thus create a strong incentive for distributors to merchandise this product to the detriment of regular milk sales.

This set of circumstances creates quite an enigma, since either extreme could produce market disruption; therefore, pricing limits within which the Bureau of Milk Stabilization must work are relatively narrow.

The problems inherent in a milk-fat and SNF pricing program for milk received from dairy farmers are many and complex. In considering such a program, it is important to know the potential pitfalls in order to be in a position to avoid them.

The dangers inherent in this program are a breed war, a threat to the quality of standard milk and an artificial stimulation to the importation of SNF from out-of-state.

In connection with a preference for milk from one breed of cattle over another, it is desirable that a change in pricing procedure does not act in such a way as to unduly stimulate the supply of milk from one breed in preference to another and that milk from all the regular commercial herds maintains its place in the market.

An objective in pricing milk on a SNF basis is that the quality of standard milk does not suffer. Under the present pricing procedure with milk being paid for on the basis of the volume of skim milk, there is an incentive to maintain high quality because the price for skim milk of a higher SNF test is the same as skim milk of a lower SNF test. In changing over to pricing skim milk not on a volume basis, but on a SNF content basis, skim milk with a lower SNF content will actually cost less than skim milk with a higher SNF content.

The legal minimum standard for the solids-not-fat content of regular milk is 8.15 percent. The average SNF content of the regular milk on the market today is substantially higher than this minimum amount and it is important that a change in pricing method does not stimulate a lowering of the SNF content of regular milk, thereby lowering its quality.

Another pitfall to avoid is the potential of stimulating an out-of-state supply of SNF, either wet or dry.

Presently, no Grade A skim milk solids are imported into the State to be used in Class 1 products. However, if a price per pound of SNF were established at a level substantially higher than the cost of procuring SNF from out of state, an economic environment conducive to importing solids would be created.

These hazards must be given due recognition in formulating a pricing program based on the milk-fat and SNF content of milk.

There are several alternative methods of pricing milk on the basis of the solids content. However, at the present time, three methods seem to provide the most promise.

The first method that would naturally come to one's mind in considering pricing milk on solids content basis would be a method that established a minimum price directly for each of the two types of solid components. Such a method would provide a price per pound of milk-fat component and a price per pound of SNF component. Using this method, it would be

very simple to assign the present milk-fat minimum prices that are in effect to the milk-fat component, and use the present minimum prices per hundredweight of skim milk to arrive at a comparable value per pound of solids-not-fat. Under this method, the present solids-not-fat prices would range from 19 to 23 cents per pound in the fall and winter months and from 15 to 19 cents per pound in the spring and summer months.

This method of pricing might have a very drastic impact on the market because the relatively high price for SNF could stimulate an out-of-state supply. Also, this method offers very little by way of softening the impact of the other hazards previously mentioned.

Another method that is receiving consideration might be described as a plant pool method.

A reference to the plant pool method appeared in 1942 in an article entitled "Paying Producers for Solids and Solids-Not-Fat in Milk" by Rudolph K. Froker and Clifford N. Hardin, Wisconsin Research Bulletin No. 143. The basic feature of this plan was for the distributor to continue to pay the same hundredweight price for milk but to distribute the proceeds among producers upon the basis of the milk-fat and solids-not-fat tests. A modification of this plan which basically consisted of continuing the present minimum price as established for the milk-fat component having the present minimum hundredweight price for skim milk paid into a plant pool by the distributor, who then divides the total dollars paid into the pool for skim milk by the total pounds of SNF received to determine a price per pound of SNF. Producers then would receive this determined price per pound of SNF for the SNF component of the milk that they shipped. Under this proposal, the processor would pay the same price that he pays now but this money would be divided among producers on the basis of the solids components of their milk.

The main advantage of this method is that it would remove any threat to the quality of standard milk because the distributors would continue to purchase the skim milk components on the same basis as before.

A third basic solids pricing procedure is called the "fluid premium" method. Under this method, a value is established and assigned to the three components of milk; the three components being the milk-fat content, the SNF content, and the residual component which, theoretically, is water. Now this is not just ordinary water. It is more than that. It is the fluid carrier of the other two components. It is a representation of location differentials and it is a component that cannot be obtained by any other means than obtaining fluid milk from the dairy cow because milk of a higher than minimum SNF content cannot be standardized down by the addition of water. Therefore, this fluid has a value. The proposal made using this method would establish the milk-fat value at the present minimum milk-fat price, a minimum price for SNF that is competitive to the open market price for SNF, and the price for the third component would be the difference between the present minimum price converted to a hundredweight basis and these established prices for fat and SNF.

By way of example, if the present minimum prices for the Los Angeles Marketing Area of $1.04 per pound milk fat and $1.83 per hundredweight of skim were used, a hundredweight of milk testing 3.8 percent milk fat would cost $5.71. If the value of the milk fat in this hundredweight were subtracted and the value of 8.8 pounds of solids at the rate of 18½ cents per pound were subtracted, there would remain approximately 13 cents not accounted for. This 13 cents, then, would be the price for the third component which is the fluid.

The main advantage of this proposal is that it provides for the pricing of SNF on a competitive basis and thus removes any stimulation to import SNF.

A number of suggestions that modify or combine features of these three basic plans have been considered. One such suggestion would require that the present prices be paid by distributors into a plant pool but that producers would draw payments from the pool on the basis of the milk-fat, SNF and residual fluid component of the milk.

No description of the impending new pricing program in California is complete without an explanation of the part played by the dairy industry study committees.

The Director of Agriculture has appointed representative leaders of the dairy industry to meet with members of his staff to study the problems facing the dairy industry in California. These members serve without compensation and meet in Sacramento on call by the Director.

There are four such committees: a market milk producer committee, a market milk processor committee, a manufacturing milk producer committee and a manufacturing milk processor committee.

The market milk producer and processor committees have worked jointly along with the staff of the department for a period of several months studying the problems of establishing a new pricing method based on the solids components of milk. Their work has been of great value in several ways. Their meeting has provided a forum to discuss the pros and cons of the several pricing methods. This group sitting together has provided a medium for resolving many of the conflicts between producers and processors and between producers divided on the basis of breed of dairy cattle and section of the State. These men, being leaders in their area and experts in their field, have provided the Director with expert advice. Also, these meetings have helped the Department and the dairy industry prepare for the public hearings that must necessarily be called and held to establish minimum wholesale and retail prices for low-fat milk and minimum producer prices based upon the milk-fat and SNF components of milk.

These two committees sitting jointly have recommended that public hearings to consider inaugurating the new dairy product, low-fat milk, and establishing a milk solids producer pricing method be called beginning in February 1962, with April 1, 1962, as the effective date for the new marketing orders.

The dairy industry in California is making a major adjustment in its operations to meet the new market emphasis on the solids-not-fat component of milk.

The Many Ways of Measuring Solids-Not-Fat In Milk

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The 1961 session of the California Legislature passed a bill which, among other things, provides that the solids-not-fat content of market milk will be a factor in its pricing structures. This bill, now law, has focused the attention of the dairy industry on a problem which it has long considered but never before has implemented.

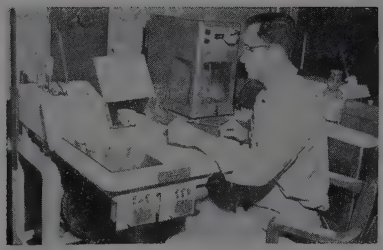
The fat content of milk has long been the chief yardstick by which its value has been measured. Today increasing emphasis is being given to all milk nutrients, so that the breeder, the dairy farmer, the milk processor, the nutritionist, and the consumer are each interested in both the fat and the solids-not-fat in milk. The solids-not-fat are composed of the protein, milk sugar, and minerals in the milk. An accompanying article in this issue of The Bulletin discusses economical aspects relating to solids-not-fat in milk; this paper will deal with methods used to measure the solids-not-fat content.

Whenever the results of his work are to be used to determine the payment for the product, a person who tests milk for its solids-not-fat content must hold a valid non-fat milk solids tester's license issued by the Bureau of Dairy Service. The procedure used must be one approved by the Bureau of Dairy Service. If a lactometric method is used, the lactometer must be of certified accuracy, as described later in this paper.

An accurate fat test is an essential factor in the calculation of the solids-not-fat. Since accurate and rapid routine fat tests are well known, they will not be discussed here.

The basic method for solids testing is the gravimetric procedure, as outlined in the Official Methods of the Association of Official Agricultural Chemists.[10] This requires chemical laboratory equipment and a skilled technician. It is in reference to this method that the accuracy of all other procedures is compared. In the "A.O.A.C." method a known weight of milk, about 2.5 grams, is placed into an accurately weighed flat-bottomed dish, heated on a steam bath for 10 to 15 minutes and then placed in an air-oven held at 98°-100° C. This procedure drives off the water, leaving the milk solids. After the dish has cooled to room temperature, it is weighed and the percentage of milk solids is calculated. The fat percentage, previously determined, is subtracted from the total solids and the remainder represents the milk solids-not-fat.

* In charge, dairy laboratory.



Chemist, M. Monier, making total solids tests on the Mojonnier equipment.

This drying procedure takes too long for routine use. A modified method, devised by T. Mojonnier about 50 years ago is more commonly used by the dairy industry. Here, about two grams of milk are weighed into an aluminum dish and dried to a uniformly light-brown color on a hot plate heated to 180° C. The dried dish is placed for 10 minutes in a vacuum oven held at 100° C. The dish is then cooled to room temperature, weighed and the percentage of total solids calculated.

Other gravimetric procedures have been used to a limited extent. The Dietert-Detroit Moisture Determinator is used in some dairy laboratories in place of the more expensive Mojonnier apparatus. It employs hot-air circulation to dry the sample, and will take four samples at a time, whereas the Mojonnier equipment will dry eight in about the same time. The Brabender Moisture Tester which will handle 10 samples in about 45 minutes, is used in some laboratories, but it does not have the accuracy of the methods just described. It combines a drying oven with a balance which has an accuracy of 0.002 gram, whereas the analytical balance used with other tests will weigh to 0.0001 gram. A different type of moisture-testing apparatus is represented by equipment, such as the Cenco Tester and the Ohaus Moisture Determination Balance, which combine a balance and an infrared drying unit. These instruments handle but one sample at a time, and do not have the accuracy of methods which employ an analytical balance.

Published data show that the A.O.A.C. method and the Mojonnier procedure have essentially the same degree of precision; the other methods are more variable and tend to give results which usually are from 0.1 to 0.2 percent lower than the A.O.A.C. method.

Methods that involve a chemical reaction are useful only for products of comparatively low moisture content and so are not applicable to fluid milk products. Thus, the Karl-Fischer titration for water and the Olivo Moisture Meter which measures the pressure of acetylene gas generated when water reacts with calcium carbide have found little application in the dairy laboratory.

Since gravimetric procedures are time-consuming and require costly equipment, much attention has been given to indirect methods to determine milk solids. One of the best known is that of Jacobson,[10] who in 1936 devised a formula, based on milk from the New England States, which states that the solids-not-fat of a milk is equal to 0.4 times its fat content plus 7.07. For example, if a milk contained 4 percent fat, its solids-not-fat content is (4 x 0.4) + 7.07 or 8.67 percent. Formulas of this type are intended for use with mixed milk as it comes from the herd, and not for milk which may have been standardized in the dairy to a given fat and/or solids-not-fat content. In 1951, a formula relating to California milks was published by Jack and coworkers [6] at the University of California at Davis. This formula is very similar to that of Jacobson and says that the solids-not-fat are equal to 0.444 times fat plus 7.07. Many other formulas have been proposed but have found little application.[3]

Examples of the results obtainable with formulas are given in Tables I and II. The fat tests and gravimetric solids-not-fat figures are taken from a recent study on the composition of California milk.[11]

TABLE I

Estimation of Solids-Not-Fat by Formula

		Jacobson	*Jack*
Fat	3.82 [1]	---	---
SNF	8.58	8.60	8.77
Fat	3.85 [2]	---	---
SNF	8.74	8.61	8.78
Fat	3.90 [3]	---	---
SNF	8.63	8.63	8.80
Fat	4.11 [4]	---	---
SNF	8.71	8.71	8.89
Fat	4.64 [5]	---	---
SNF	8.95	8.92	9.13
Fat	4.96 [6]	---	---
SNF	9.02	9.05	9.27

[1] Average of 41 samples from vicinity of Visalia.
[2] Average of 86 samples from vicinity of Davis.
[3] Average of 36 samples from vicinity of Newman.
[4] Average of 38 samples from vicinity of Willows.
[5] Average of 35 samples from vicinity of Petaluma.
[6] Average of 22 samples from vicinity of Fernbridge.

Statistical examination of much published data indicates that the solids-not-fat in *mixed herd milk* may be estimated to within 0.29 percent of the gravimetric results in two-thirds of the samples tested by the Jacobson formula.

Next to be considered are the formulas for solids-not-fat based upon the fat content and specific gravity of the milk. As in the case of the Jacobson type formula, errors are minimized when mixed milk, rather than that of an individual cow, is tested, although this laboratory did have very good results on milk from individual cows.[4]

The specific gravity of milk may be measured by several methods, such as by the use of the pycnometer, the Westphal balance and the lactometer. The pycnometer gives accurate results, but is slow and awkward for practical use. The Westphal balance gives a result which is a compromise between the accuracy of the pycnometer and the speed of the less accurate lactometer.

The lactometer is a hydrometer with a scale which indicates the specific gravity of milk in terms of lactometer degrees. A lactometer degree is 1,000 times the specific gravity minus 1,000, or more simply, the last two figures of the specific gravity value, read to the third decimal place. Thus, a specific gravity of 1.0325 is equivalent to a lactometer reading of 32.5 The older type of lactometers often read only to a whole degree, but instruments are available with scales divided to 0.1 or 0.2 lactometer degree. The state regulation requires that the instruments to be certified for accuracy must be calibrated to not less than 0.5 lactometer degree and to be accurate to within 0.5 lactometer degree. To facilitate reading the instrument, the writer recommends that the length of scale representing one lactometer degree should be at least 0.5 cm or approximately one-fifth inch. For routine use, the lactometer need only read between 25 and 37 at 60° F. The colored areas on the scale on some lactometers, which are intended to indicate skimming or added water, are of no practical use. The Dairy Laboratory of the Division of Chemistry in the State Department of Agriculture examines lactometers and certifies the accuracy of those that meet these requirements by lightly sandblasting the letters "D.B." on the bulb of the lactometer. A detailed paper on the lactometer and its use was published by the writer several years ago.[7]

The accuracy of the lactometer is determined by comparing its reading when floating in homogenized milk with the known specific gravity of the milk. The specific gravity of the milk is determined by means of a carefully calibrated pycnometer or with a standard lactometer which has been calibrated by comparison with pycnometer readings. Various points on the lactometer scale are checked by diluting the milk with water or by increasing its specific gravity with the addition of evaporated milk. In each case, the exact specific gravity of these test solutions is known.

Most work with the lactometer in this country has made use of the Babcock formula, $SNF = 1/4L + 1/5F$ where L is the lactometer reading at 60°F and F the fat content of the milk tested. By the use of this formula one may, as a rule, expect results well within 0.2 percent of the gravimetric results. As an example, recently four samples of milk were tested here which had been standardized for fat content and fortified with milk solids. The results given in Table II compare the solids-not-fat obtained by Mojonnier and lactometer and the use of the Jacobson and Jack formulas. The erroneous result that may be obtained by these formulas on milk with added solids-not-fat is well indicated in this table.

TABLE II

Lactometer Results on Standardized Milk

Fat	*Mojonnier SNF*	*Lactometer 60° F.*	*Jacobson formula*	*Jack formula*
3.70	9.37	9.35	8.55	8.81
3.65	9.97	9.83	8.53	8.69
3.90	9.24	9.22	8.63	8.80
4.05	9.88	9.84	8.69	8.87

Early work done in the laboratory,[4] is in line with the above lactometric results and shows that the average SNF of milk could be determined within 0.02 of the gravimetric results.

The use of the lactometer at 60° F. has been criticized since the specific gravity of a milk sample is not constant. At the time of milking, the fat globules are liquid and, if the milk is not cooled, the globules will remain liquid at 60° for 12 to 15 hours. As the globules cool and gradually solidify, they contract and become smaller in volume. As a result, the volume of milk will also decrease somewhat and so its specific gravity will increase, since the same weight of milk will occupy less volume. This is

A pycnometer (specific gravity bottle) used to check the accuracy of lactometers, such as those shown in foreground.

known as the "Recknagle effect." If this factor is not taken into consideration, a solids-not-fat determination on relatively fresh milk may be 0.1 percent or more too low. However, this factor may not be as important today as it was 10 years ago. Today much milk is held at a low temperature in farm tanks over a period of two, three, or more milkings or has been mixed with so much pooled milk that a sample taken at the processing plant probably has reached its maximum specific gravity. As a result, reliable readings may be expected when the lactometer is used at 60° F. A limited investigation on this point is now being undertaken here.

Various procedures have been proposed to give accurate specific gravity determinations. Some methods involve heating the milk to 95° F. or higher, and then cooling to 60° or 68° before taking the lactometer reading.[3,4,9] The most recently proposed method is to heat the milk to 102° F. and to take the specific gravity at that temperature with a specially calibrated lactometer.[12, 13] Since the lactometer is used at 102° F., the usual Babcock formula does not apply and use is made of the formula

$$\text{SNF} = \frac{0.33\,\text{F} + 273\text{L} - 0.40}{\text{L} + 1{,}000}$$

F is the fat content of the milk and L the lactometer reading at 102° F. As in the case of the 60° F. lactometer, tables are also available which make it unnecessary to use the formula in making the solids-not-fat test with the 102° lactometer.

Published results on these procedures are not conclusive. Tests made on milk measured at 102° F show a variation from the gravimetric results of from −0.18 to +0.19 percent. This is essentially the variation that is obtained when milk is measured at 60° F. A factor in favor of the 60° reading is that a variation of about 10° F may be tolerated in the temperature of the milk and corrected for in the test. In the work previously mentioned it was found that the correction of +0.1 lactometer degree for each degree of temperature above 60° F. (up to 65°) and −0.1 lactometer degree for each degree of temperature below 60° F. (down to 55° F.) gave correct results. At temperatures below and above this range the correction is not as satisfactory.[4]

The ability to correct for temperature variation appears to be more limited when the 102° lactometer is used. Published directions indicate that the sample should not vary more than 2° F. from 102° F., in which case the correction factor is 0.2 lactometer degree for each degree of temperature.[12, 13]

It would appear that plant-operation conditions would indicate whether the 60° or 102° lactometric procedure should be used.

Laboratory technician, James Moore, making a lactometer reading.

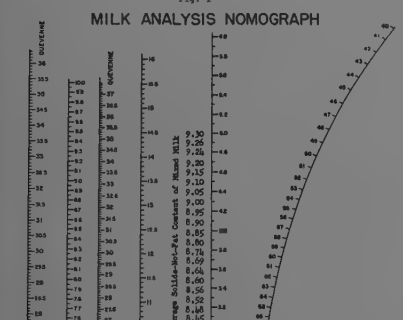
In some places, it may be convenient to warm the milk to about 95° F. for the Babcock fat test and then to 102° for the lactometer test. In other places, daily samples may be warmed to 60° for the lactometer test and then, if necessary, up to about 95° for the fat test. In the case of composite samples, it may be necessary to warm to about 95° F. for the fat test and then cool to 60° for the lactometer reading.

If the milk is heated and then cooled to 60° F. in order to eliminate any element of uncertainty due to the Recknagle effect, the usual Babcock formula for solids-not-fat may not apply. It was found[4] that a correction of +0.2 was needed, so that the modified formula in this case is SNF = 1/4 L + 1/5 F + 0.2. Work is now being undertaken to see how generally this factor applies under present day conditions. If this work indicates that this factor or any other factor is warranted, changes will be made in the formula acceptable for use by licensed nonfat milk-solids testers.

A nomograph, shown in reduced size in Fig. 1, was devised in order to simplify the calculations needed to obtain solids or solids-not-fat.[8]

The plastic bead lactometer is a new development.[2] In this procedure, the milk to be tested is warmed to 104° F. and placed in a small jar. This jar contains 10 small, plastic balls or beads which differ from each other in specific gravity by one lactomer degree. The 10 balls cover the range from 25 to 34 lactometer degrees. When the milk in the jar has cooled to 68° F., the number of beads on the bottom of the jar is counted. The solids-not-fat in the milk sample is determined by a formula which relates the fat content of the milk and the number of beads counted. The formula is SNF = 913 — 0.279 B + 0.307 Fat, where B is the number of beads on the bottom of the jar. Published results[1] indicate the method does not have the accuracy of the lactometric procedure, and of 1,873 samples tested, more than 25 percent of them varied from the gravimetric results by more than 0.2 percent.

Fig. 1



No temperature correction is made when the plastic bead method is used between 68° and 76° F. This may in part be accounted for by the relative insensitivity of the method, each bead being equivalent to a whole lactometer degree. If one were satisfied with this degree of sensitivity, no correction would be needed with the 60° lactometer, since its readings would vary only one lactometer degree over a range of 10° F.

Another specific gravity procedure has been proposed recently. This is the Banco Gradient Balance, an adaptation of the falling-drop method of measuring density values. This procedure uses a single drop of milk, which is placed into a graduated tube containing a special mixture of standardized light and heavy liquids. This mixture varies uniformly in specific gravity, so that the densest portion is at the bottom of the tube and it gradually becomes lighter towards the top. The drop of milk sinks until it reaches the section which has the same specific gravity as the milk. The specific gravity value is read from the scale on the tube and the solids-not-fat may be calculated by formula or obtained from a table of values. No data is as yet available on the use or accuracy of the procedure. Since it is a specific gravity method, its accuracy would be expected to be in the range of the indirect procedures.

It is possible that in the future some electronic device may be developed which will simplify fat and solids testing. An approach towards this end has been made with the "Darisonometer." This instrument measures fat and solids by applying to a sample of milk high-frequency sound waves, the so-

called ultrasonic waves. These sound waves move with different speed through liquids of different composition; the higher the solids content, the faster the waves pass through it. With this instrument, the milk sample is divided into two portions, one part is heated to 122° F., the other cooled to 57° F. The claim is made that at 57° F. the fat content does not influence the speed of the sound waves and the results obtained indicate the solids-not-fat. At 122° F., the result obtained represents the sum of fat and solids-not-fat. The instrument automatically subtracts these readings from each other and the results, read on dials, indicate fat and solids-not-fat. From the limited information available on this procedure, it appears its accuracy is comparable to that of other indirect methods, such as the lactometer, which depend upon physical measurements.

All available information leads one to believe that the lactometric determination of solids-not-fat has the potential accuracy of the gravimetric procedure. Some variation in lactometric results may be attributed to a possible error in the fat test. Although most bottles are accurately calibrated, the California Agricultural Code permits an error not to exceed 0.1 percent in the calibration of any part of the scale on a Babcock milk-fat test bottle. In a 3.5 percent fat milk, an error of 0.1 percent in the fat content is equivalent to 2.85 percent of the fat content of the milk. An error in 0.1 percent in the fat test means a change of only 0.02 percent in the solids-not-fat content of the milk, when the lactometer is used at 60° F.

By similar reasoning, an error of 0.1 lactometer degree, according to the Babcock formula, is equivalent to 0.025 percent of the solids-not-fat. This is equivalent to 0.29 percent of the solids-not-fat in a milk that contains 8.6 solids-not-fat. The Bureau of Dairy Service regulations permit an error up to 0.5 degree in the calibration of a lactometer. This could permit an error of about 1.5 percent in the solids-not-fat determination—nearly one-half that which an error of 0.1 percent in the fat test would cause. Since the dairy industry has long tolerated the possibility of an error of 0.1 percent in its fat tests, it cannot criticize a procedure which may make an error of smaller magnitude in the less costly solids-not-fat.

Thanks are due to Mr. A. E. Reynolds, Acting Chief, and Mr. R. L. Van Buren, Area Supervisor, Bureau of Dairy Service, for suggestions used in the preparation of this paper.

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Systematic Status of the Pseudococcus maritimus-malacearum Complex of Mealybugs

(Homoptera: Coccoidea: Pseudococcidae)

By R. F. WILKEY [1] and
HOWARD L. McKENZIE [2]

Introduction

For more than 40 years attempts have been made to determine whether or not more than one species of mealybug is involved under the name *Pseudococcus maritimus*, a species described by Ehrhorn in 1900. In 1918, Ferris recognized it as a valid segregate and placed under it the following list of synonyms: *Pseudococcus obscurus* Essig, *P. bakeri* Essig, and *P. omniverae* Hollinger.

In the meantime, the University of California, Department of Biological Control, Citrus Research Center and Agricultural Experiment Station, Riverside, California, was conducting experiments with what was currently recognized as *maritimus*, and certain of these investigators believed quite definitely that more than one species was involved. Their reports demonstrated that a variation existed in the reaction of certain parasites toward mealybugs collected from various areas, although reared on the same host and under identical conditions. Positive differences in the number of generations of mealybugs taken from various areas were also noted. In Ferris' (1950) Atlas of the Scale Insects of North America, the following statement is made regarding this situation, "Certainly it appears that populations exist which in their physiology seem definitely to be specifically different and that must be treated as distinct species." Ferris' investigations showed no morphological bases for recognizing these species, and it was further concluded by him that the final answer to the problem would be left to others who could approach it by experimental methods. He did, however, describe a species, *Pseudococcus malacearum*, occurring on pears in Central California, and often associated with what seemed to be unquestionably *maritimus*.

The authors' approach to this problem has been basically a re-examination and systematic appraisal of type material of all North American segregates of the so-called "*maritimus-malacearum*" complex.

Species Studied in This Complex

The authors feel particularly fortunate that either type lots, or near authentically compared equivalents, have been available for examination during the course of these investigations. The following list of species, together with date described, type designation, and source of type deposit, have been here considered. (See Table I).

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[2] Associate Entomologist, University of California, Davis.

TABLE I

Species	Date	Type Designation	Material Source
Pseudococcus bakeri Essig	1909	Cotypes	Calif. Academy of Sciences
Pseudococcus capensis Brain	1912	Paratypes	U. S. Nat'l. collection of Coccoidea
Pseudococcus comstocki (Kuwana)	1902	Type & cotypes	Stanford Univ. Mus. collection
Pseudococcus malacearum Ferris	1950	Lectotype	Calif. Dept. of Agriculture collection
Pseudococcus malacearum Ferris	1950	Paratypes	Stanford Univ. Museum collection Calif. Dept. of Agriculture collection
Pseudococcus longispinus var. *latipes* Green	1917	Type material	British Museum
Pseudococcus maritimus (Ehrhorn)	1900	Type	U. S. Nat'l. collection of Coccoidea
Pseudococcus maritimus (Ehrhorn)	1900	Topotypes	Stanford Univ. Museum collection
Pseudococcus obscurus Essig	1909	Type and cotypes	Calif. Academy of Sciences
Pseudococcus omniverae Hollinger	1917	Compared with	U. S. Nat'l. collection of Coccoidea

Morphological Characters Used in Study

In the past, the principal morphological characters employed in distinguishing members of the genus *Pseudococcus* were as follows: cerarii, ducts, pores, sclerotized areas, body spines, and antennae. For example the authors have found that in *obscurus* the eighth cerarii are, in many cases, either entirely absent or greatly reduced, while *maritimus* and *comstocki* normally have the full complement (17 pairs) of complete cerarii; *maritimus* generally has more dorsal marginal oral rim tubular ducts (12 to 14 on each side), whereas, *obscurus* and *comstocki* have only five to eight of these structures on each side along margin; the oral rim tubular ducts are considerably smaller in *obscurus* as compared to the other two species; *obscurus* has one to three loculi near each eye, these apparently absent in *maritimus* and *comstocki*; and the hind tibiae of *maritimus* are parallel-sided, those of *obscurus* are obviously swollen toward middle, while the tibiae of *comstocki* are slightly swollen at base, tapering somewhat at the apex. In many cases the variation as presented by these characters is sufficient to separate the species. However, in the case of the *maritimus-malacearum* complex of species, variations in these characters occur within specimens from the same lot, and none of them is sufficiently well marked or constant to offer a solid basis for specific separation.

Up to this time very little emphasis seems to have been placed upon the precise arrangement and number of the very small translucent dots or pores present on the hind tibia and femur and at times present on other segments of hind leg. The arrangement of these structures on the hind femur is more variable than on the tibia. It was noted that on the tibia more of them consistently occur on one surface (here considered to be dorsal), than on the other. These dots or pores may also be found on the coxa and trochanter of certain pseudococcids, and have been noted on the coxa of *Pseudococcus comstocki* (Kuwana), a species which falls within the scope of this study.

It should be pointed out that these structures may be somewhat difficult to distinguish depending primarily upon the condition of the mounted specimen. Thus, a poorly cleared and stained individual would not exhibit these pores so vividly as a deeply stained and properly mounted one. This difficulty is somewhat overcome, however, by the use of phase microscopy. At present, the function of these pores is unknown.

Small and unimportant as these tiny characters appear to be, they seem to definitely provide a rather convenient taxonomic tool in segregating species of the *maritimus-malacearum* complex.

Results of Comparisons

Using the translucent pore distribution on the hind tibiae and femora has produced the following changes in the status of *Pseudococcus* species involved in this complex.

Pseudococcus maritimus (Ehrhorn)

FIGURE 1

SYNONYMS: *Pseudococcus bakeri* Essig and *Pseudococcus omniverae* Hollinger.

Examination of the type and numerous topotypes of *maritimus* shows a range of variation of the pores on the hind tibiae from 15 to 30, with an average of approximately 23.00. These structures on the hind femora range from 12 to 27, with an average of 17.88. They are absent on the hind coxae and trochanters of this species (see Figure 1). *Pseudococcus bakeri* and *P. omniverae* fall definitely within this range, and, as far as the authors have been able to determine, within the normal variation of other characters used to identify this species.

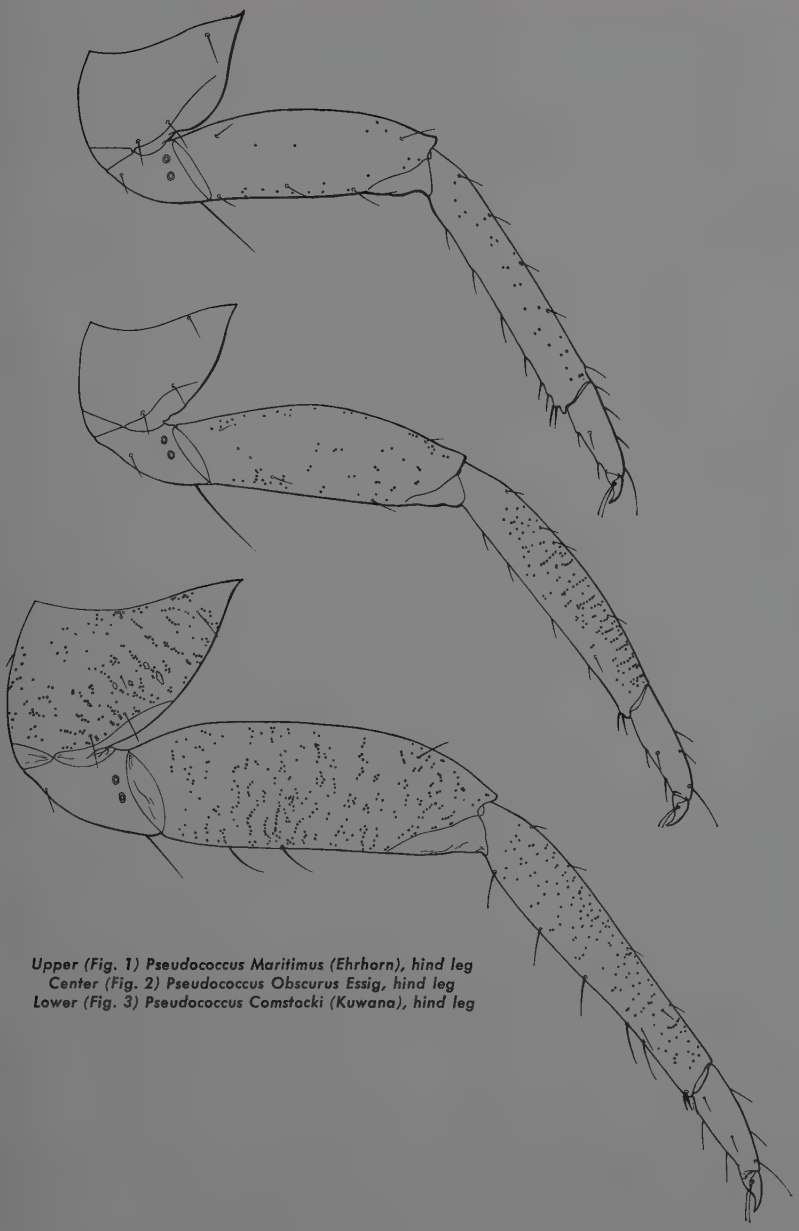
Pseudococcus obscurus Essig

FIGURE 2

SYNONYMS: *Pseudococcus capensis* Brain; *P. longispinus* var. *latipes* Green, and *Pseudococcus malacearum* Ferris.

Examination of type and cotypes of *obscurus* show a range of variation of the pores on the hind tibiae from 97 to 151, with an average of 117.0. On the hind femora these structures range from 55 to 81, with an average of 64.33. They are absent on the hind coxae and trochanters of this species (see Figure 2). *Pseudococcus capensis* Brain, *P. longispinus* var. *latipes* Green, and *P. malacearum* Ferris fall within this range of variation, and, also well within the variation of other characters used to identify this species.

The type slide of *P. malacearum* contained five specimens, four of which were mature and the fifth immature. A lectotype was selected with the other four specimens being designated as paratypes.



Upper (Fig. 1) Pseudococcus Maritimus (Ehrhorn), hind leg
Center (Fig. 2) Pseudococcus Obscurus Essig, hind leg
Lower (Fig. 3) Pseudococcus Comstocki (Kuwana), hind leg

Pseudococcus comstocki (Kuwana)

FIGURE 3

SYNONYMS: *Dactylopius comstocki* Kuwana. There are probably other synonyms, but the authors are unable to make a definite statement relative to this at the present time.

During the course of this investigation the authors became more aware of the similarity of *Pseudococcus comstocki* to *P. maritimus* and *P. obscurus*. As a matter of fact it was observed that aside from a degree more of anal lobe sclerotization (this character being extremely variable and affected by staining technique); the tendency for a dispersed group of trilocular pores in the anal lobe cerarii; and the occurrence of more numerous ventral multilocular disk pores in the midregion of the abdomen, from around the vulva to the fourth segment, there was difficulty in distinguishing *comstocki* from the other two species. Here again the arrangement and number of the translucent pores on certain segments of the hind leg offers separating morphological characters.

Examination of the type and cotypes of *comstocki* shows the pores to be present not only on the hind tibiae and femora, but also on the hind coxae. These pores are totally absent on the hind trochanters. The range of variation of these pores on the hind tibiae is from 80 to 145. On the hind femora they range from 120 to more than 340, while the hind coxae have from 99 to upwards of 250.

The number of pores on the various segments of the hind leg of this species appears to show much more variation than in the other two species. For example certain specimens designated as homotypes by the late Professor G. F. Ferris, included in the Stanford University Museum collection, exhibit fewer of these structures per leg segment than the type material.

Collective Notes

The statistical data presented above indicates that the number of translucent pores on the hind tribiae of both *Pseudococcus obscurus* and *P. comstocki* averages almost 5 times as great as compared to *P. maritimus*. The count of the femoral pores shows that the average of *P. comstocki* is almost 3½ times greater than *P. obscurus* and 12 times greater than *maritimus*. *Pseudococcus comstocki* has coxal pores whereas the other two species do not.

A few specimens here considered to be *obscurus* collected from various hosts and localities, particularly in California, show generally fewer translucent pores on the hind tibiae and femora than in the type lot (i.e. as few as 44 on the hind tibia, and 36 on hind femur). However, all other characters used to identify this species in this study agree in detail with that of the types.

Summary

Type or near type specimens of certain pseudococcid species involved in the so-called *Pseudococcus maritimus-malacearum* complex were studied to ascertain taxonomic differences.

These investigations revealed the presence of very small, translucent dots or pores evident on the hind tibiae and femora, and at times present on other leg segments, these structures appearing more on one surface (here considered to be dorsal), than on the other.

Examination of these structures on the hind tibiae of *Pseudococcus maritimus* (Ehrhorn) shows a range of variation of from 15 to 30, with an average of approximately 23.00; hind femora, from 12 to 27, with an average of 17.88; absent on the hind coxae and trochanters. *Pseudococcus bakeri* Essig and *P. omniverae* Hollinger, fall within this range, and also within the usual variation of other characters used to identify *maritimus*.

The number of translucent pores on the hind tibiae of *Pseudococcus obscurus* Essig ranges from 97 to 151, with an average of 117.0, about five times as numerous as compared to *maritimus*. On the hind femora these structures range from 55 to 81, with an average of 64.33, at least 3½ times as numerous as those of *maritimus*. These structures are absent on the hind coxae and trochanters of *obscurus*. *Pseudococcus capensis* Brain, *P. longispinus* var. *latipes* Green, and *P. malacearum* Ferris fall as synonyms of this species.

Present observations indicate that *Pseudococcus obscurus* is far more common and widespread in California than *P. maritimus*, and that numerous previous identifications of *maritimus* are actually this species.

Pseudococcus comstocki (Kuwana) is easily differentiated from either *maritimus* or *obscurus* by the presence of the translucent pores on the hind coxae; these structures are absent on the coxae of the other two species mentioned. As is shown in the drawing, the leg of *comstocki* is considerably larger than *maritimus* or *obscurus*.

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Dr. D. J. Williams, Coccidologist, British Museum, London, England, co-operated by making available for study specimens of *Pseudococcus longispinus* var. *latipes* Green, a species involved in this pseudococcid complexity. To him the authors express their utmost gratitude.

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